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Ojima et al.

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[54] **FIXING INSTRUMENT FOR SPINAL FUSION MEMBERS**

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[30] **Foreign Application Priority Data**

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[51] **Int. Cl.**[6] **A61B 17/70**; A61B 17/80

[52] **U.S. Cl.** **606/61**; 606/69

[58] **Field of Search** 606/72, 73, 69, 606/70, 71, 61, 60

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[57] **ABSTRACT**

Two posterior spinal fusion members are secured to a plurality of vertebrae which constitute a spine. The posterior spinal fusion members are fixed to both sides of the spinous processes of the vertebrae. A fixing instrument is attached to each posterior spinal fusion member. The fixing instrument includes a rod-shaped connecting member and two hooks slidably attached to both ends of the connecting member. Elongated holes are formed in the portions of the connecting member where the hooks are attached. Male screws are driven through the elongated holes. The surface around the opening of each elongated hole where the head of the associated male screw slides is formed as the bottom of a recess which is shallow on the associated end side of the fixing instrument and is deep on the connecting member side. When a hexagonal wrench is inserted in a hexagonal hole formed in the end face of the head of this male screw and is manipulated to drive the male screw into the associated hook, the head of the male screw slides on the bottom of this recess, causing the hook to move toward the connecting member. Therefore, force is applied to the two posterior spinal fusion members to shift the posterior spinal fusion members toward each other.

15 Claims, 6 Drawing Sheets

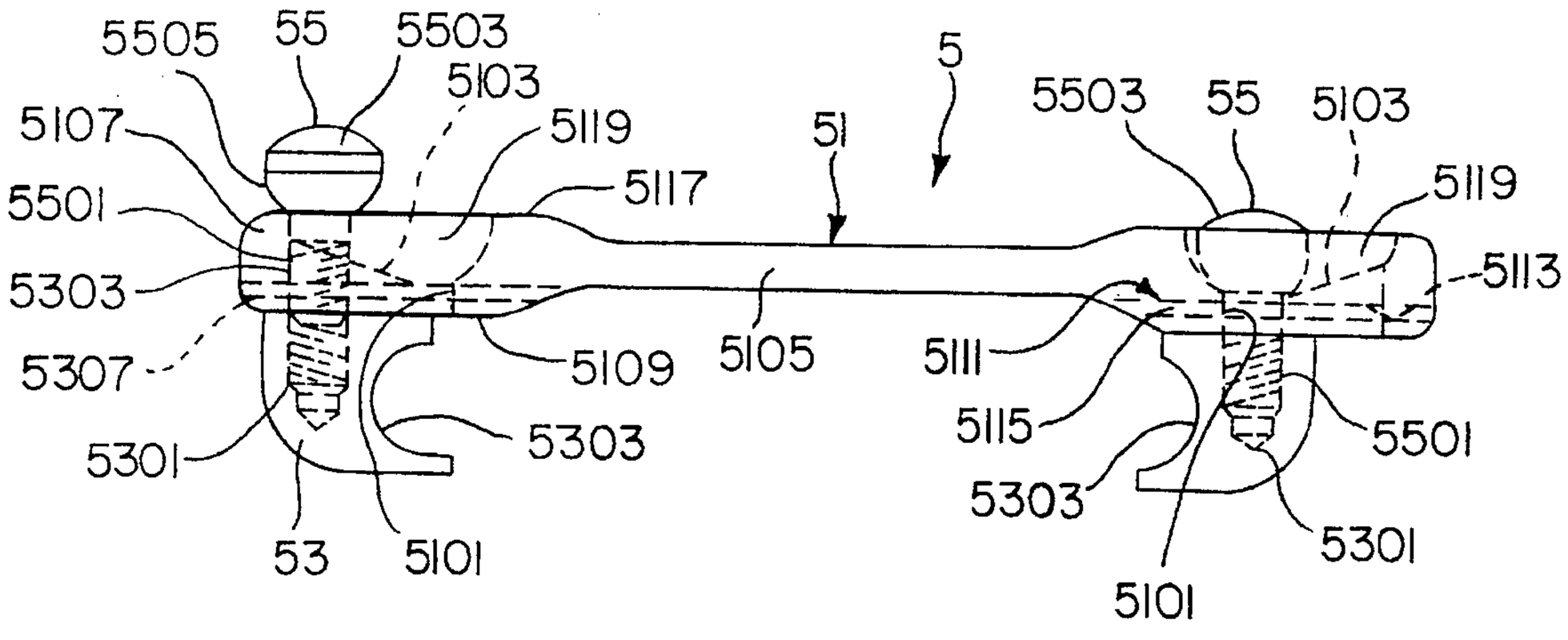
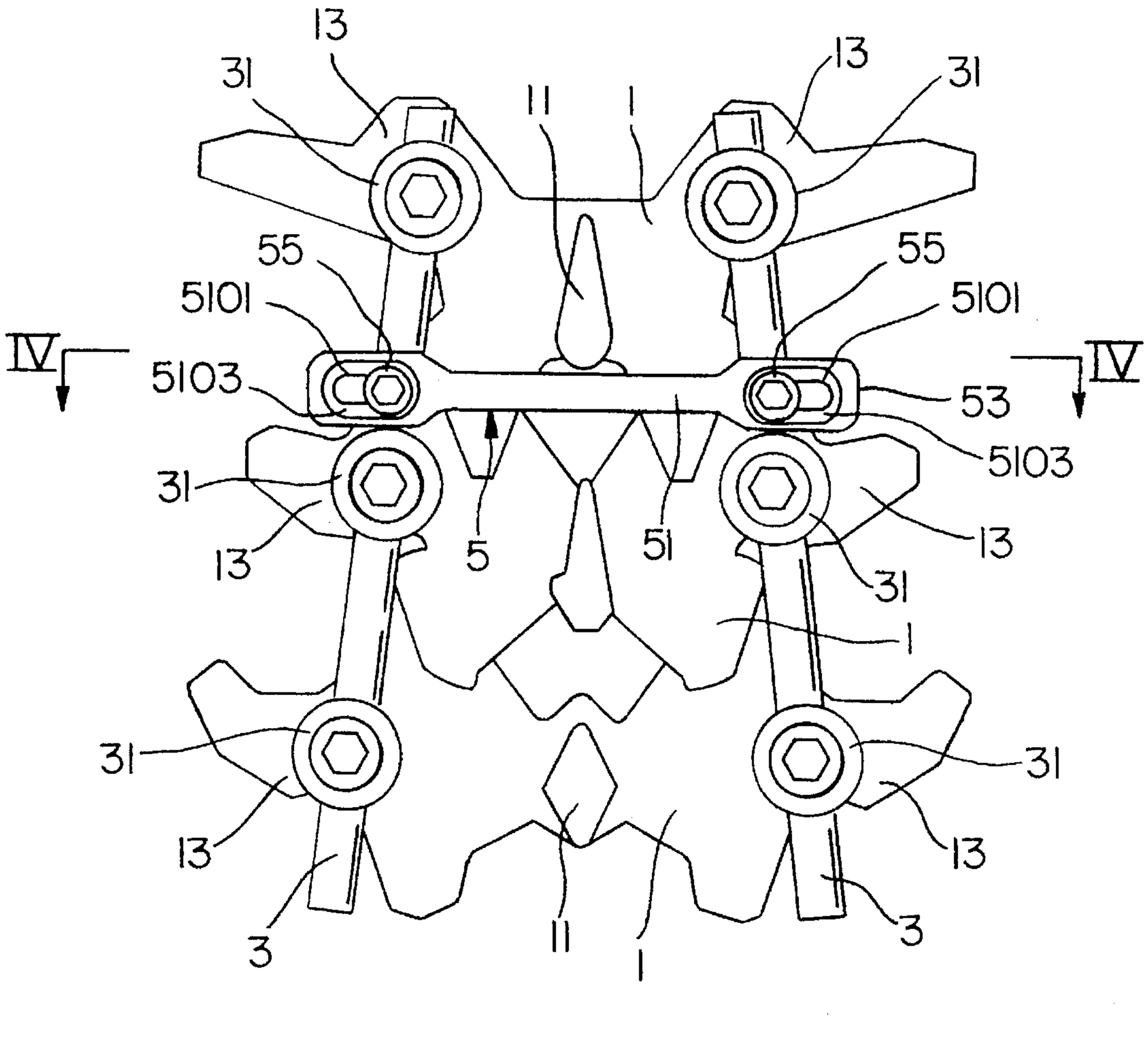


FIG. 1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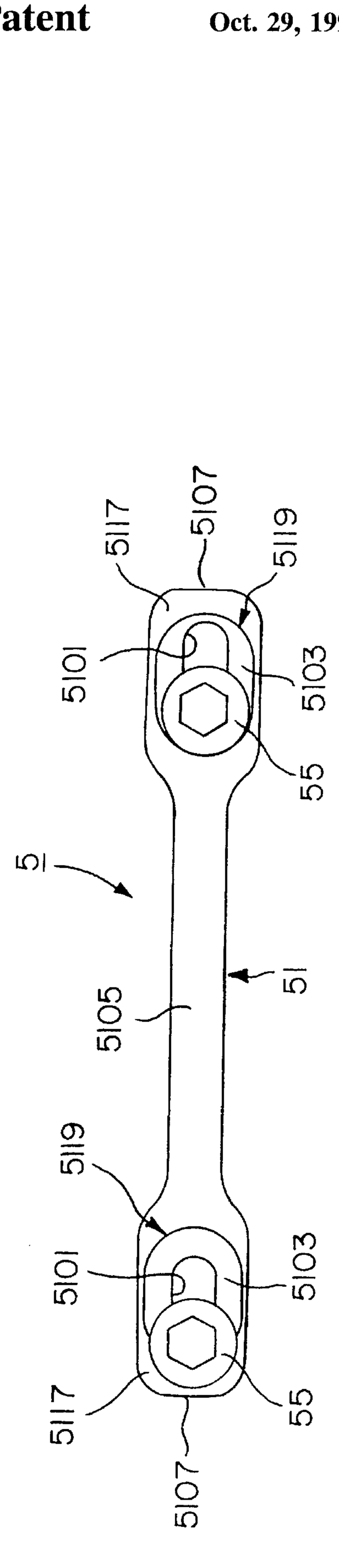


FIG. 2a

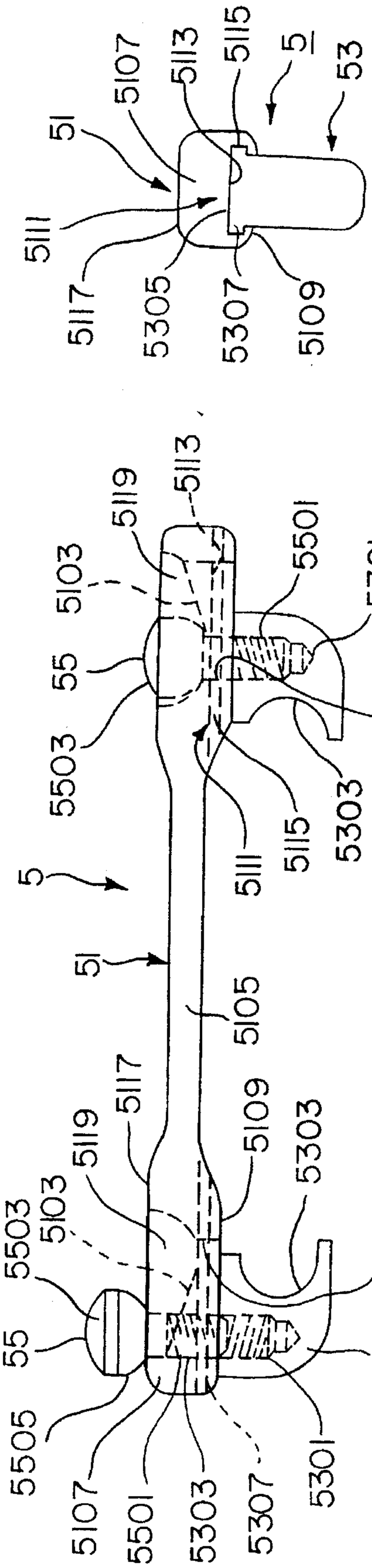


FIG. 2b

FIG. 2c

FIG. 3

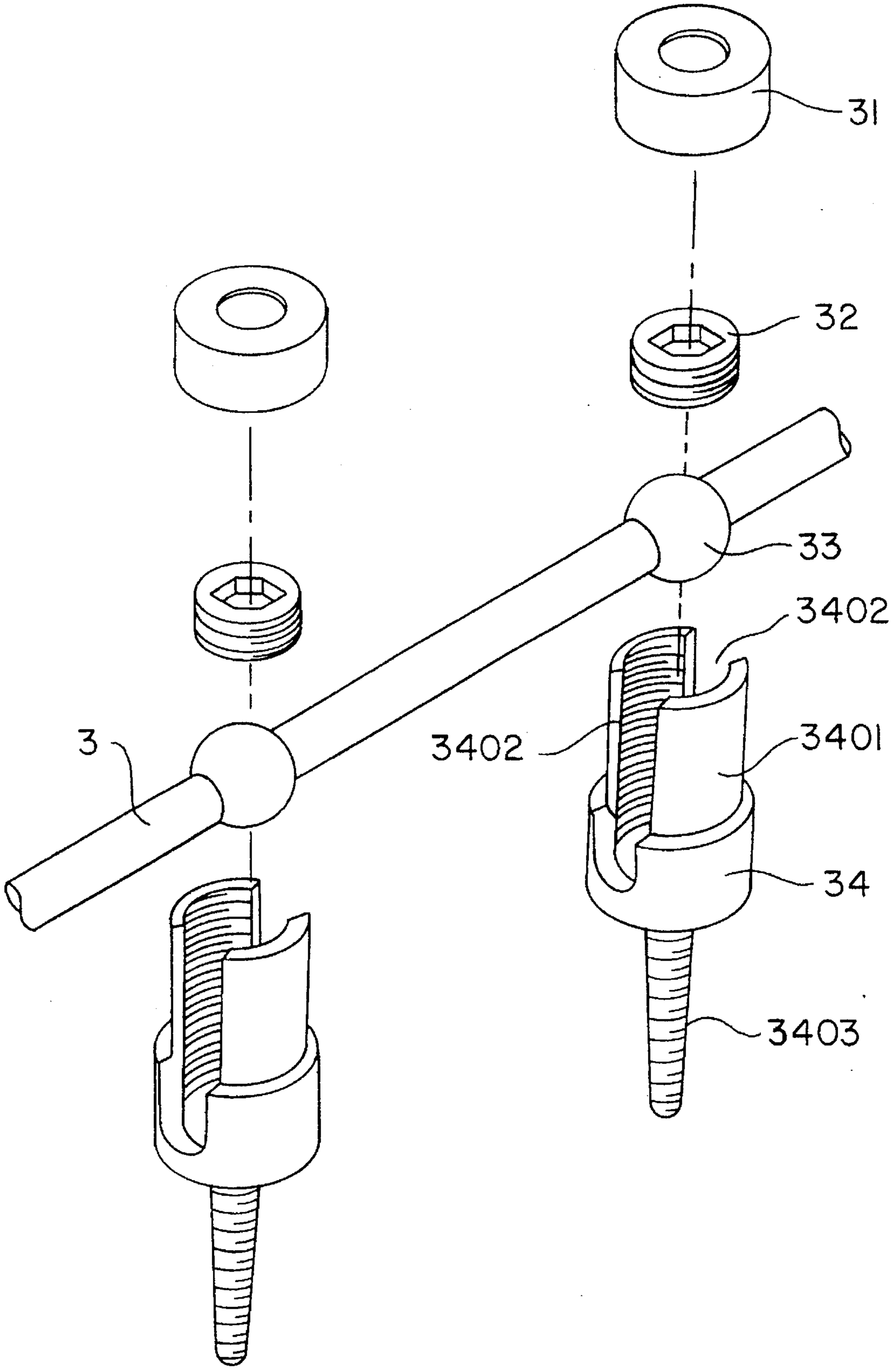


FIG. 4

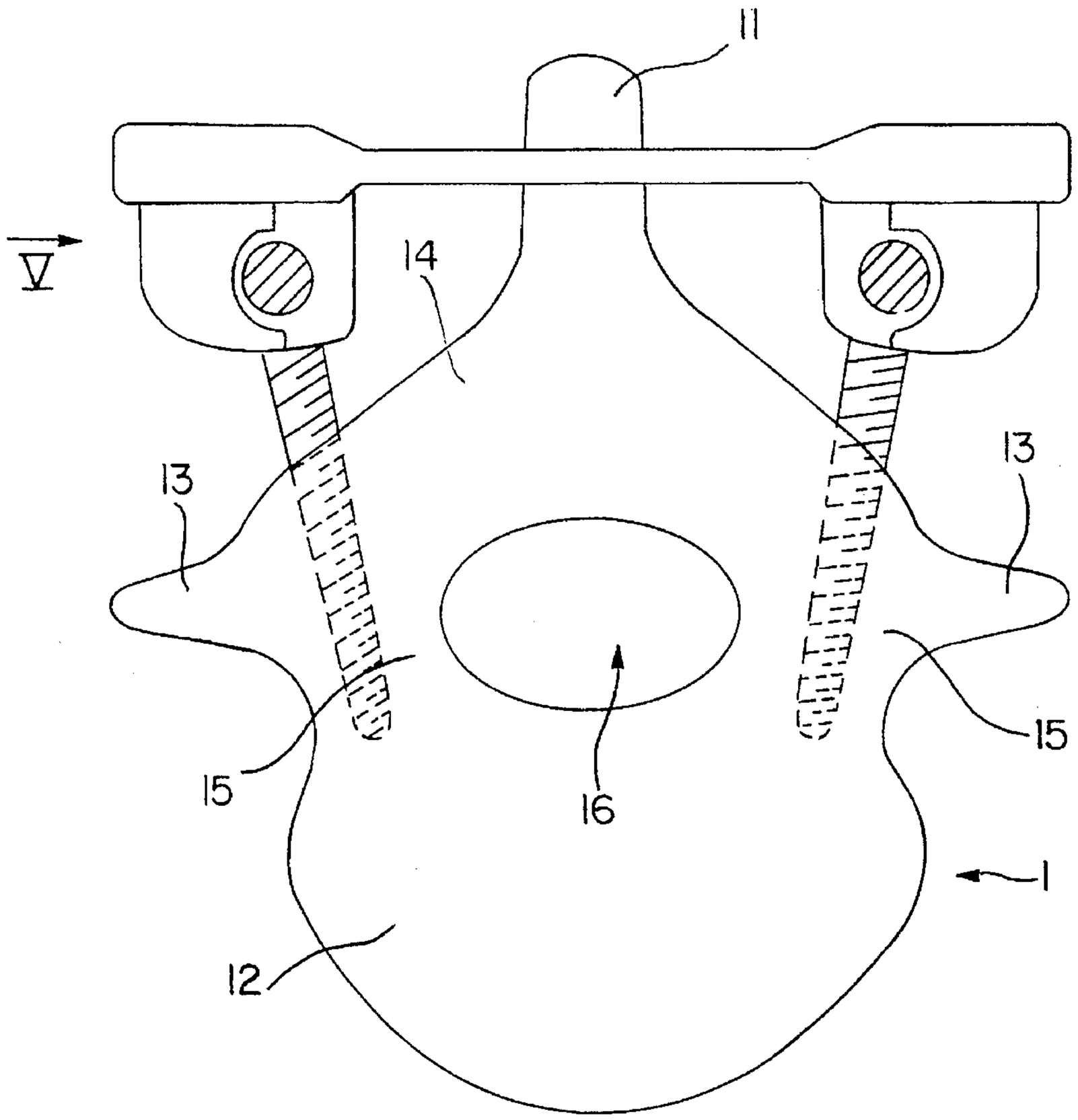


FIG. 5

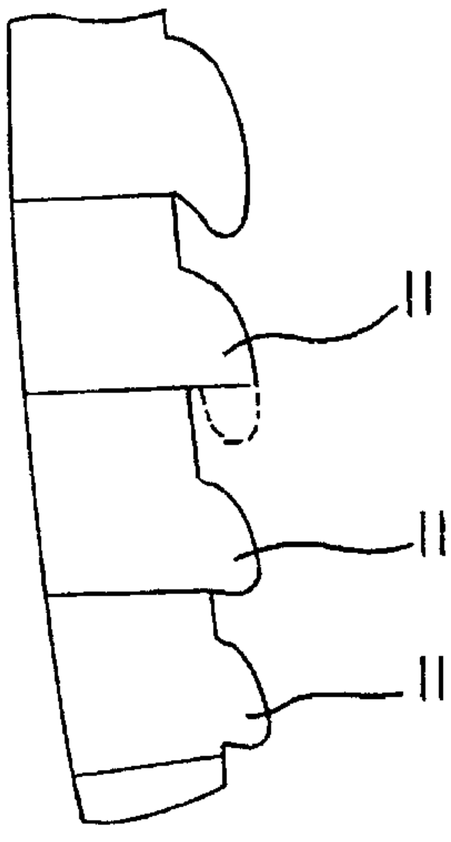


FIG. 6a

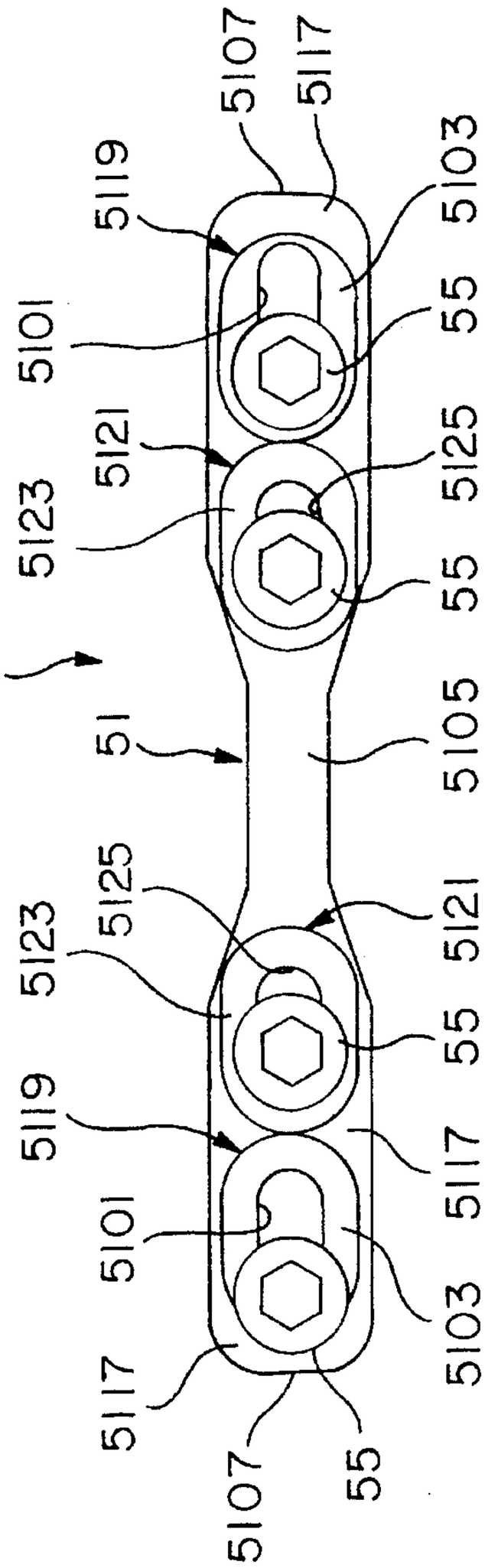


FIG. 6b

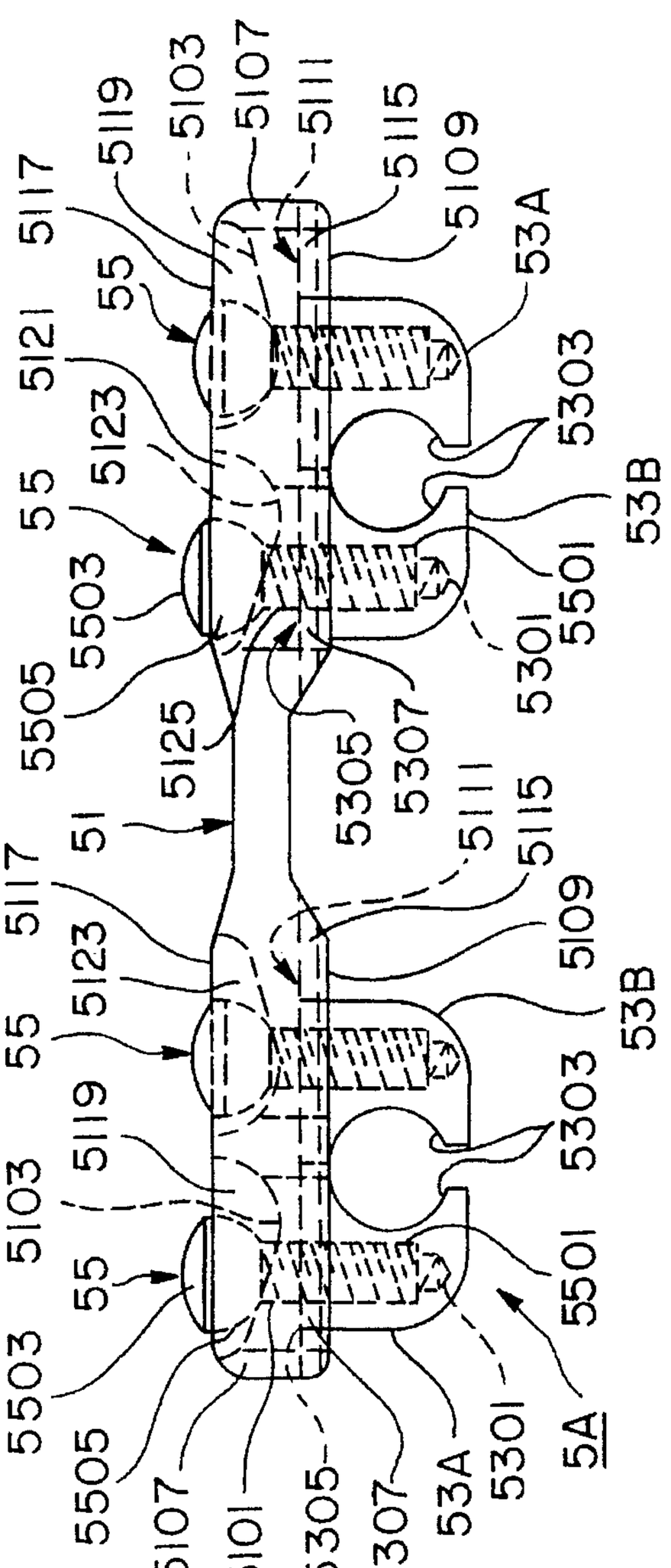
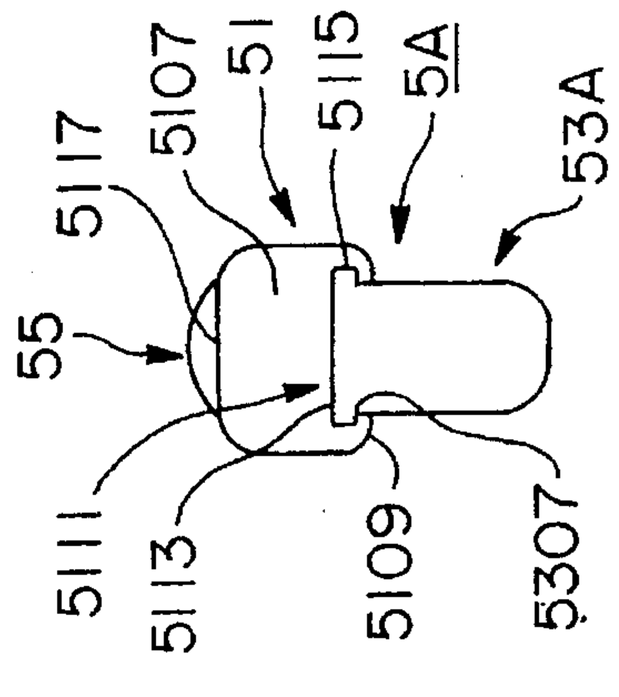


FIG. 6c



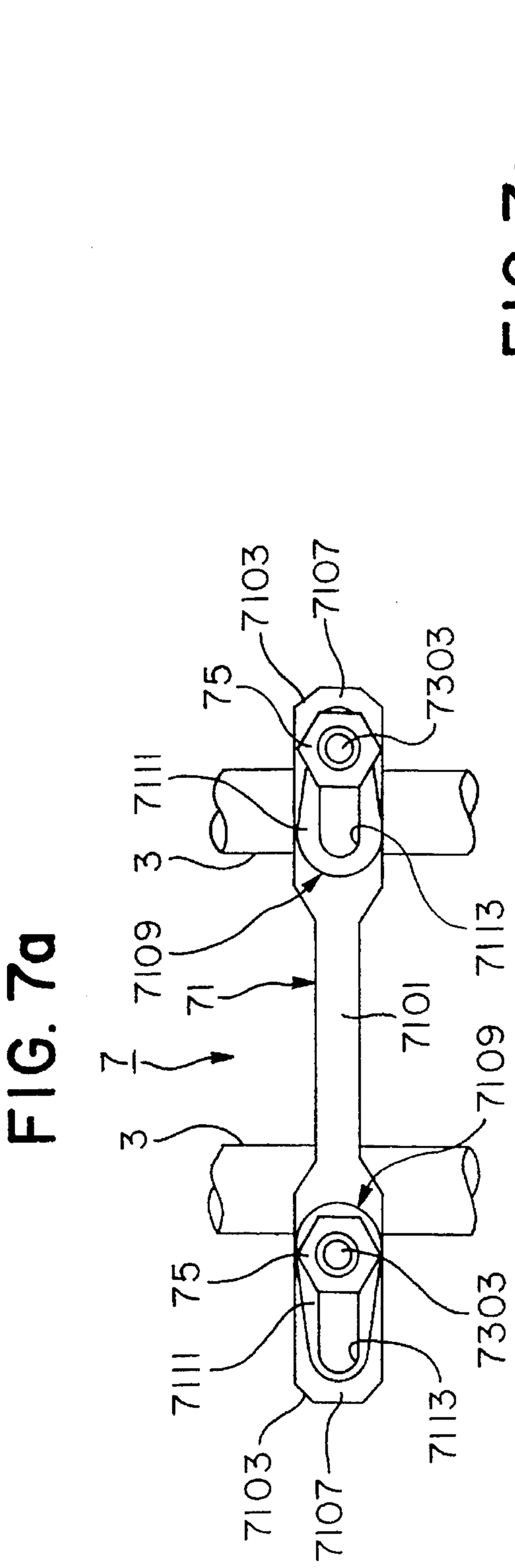


FIG. 7c

FIG. 7a

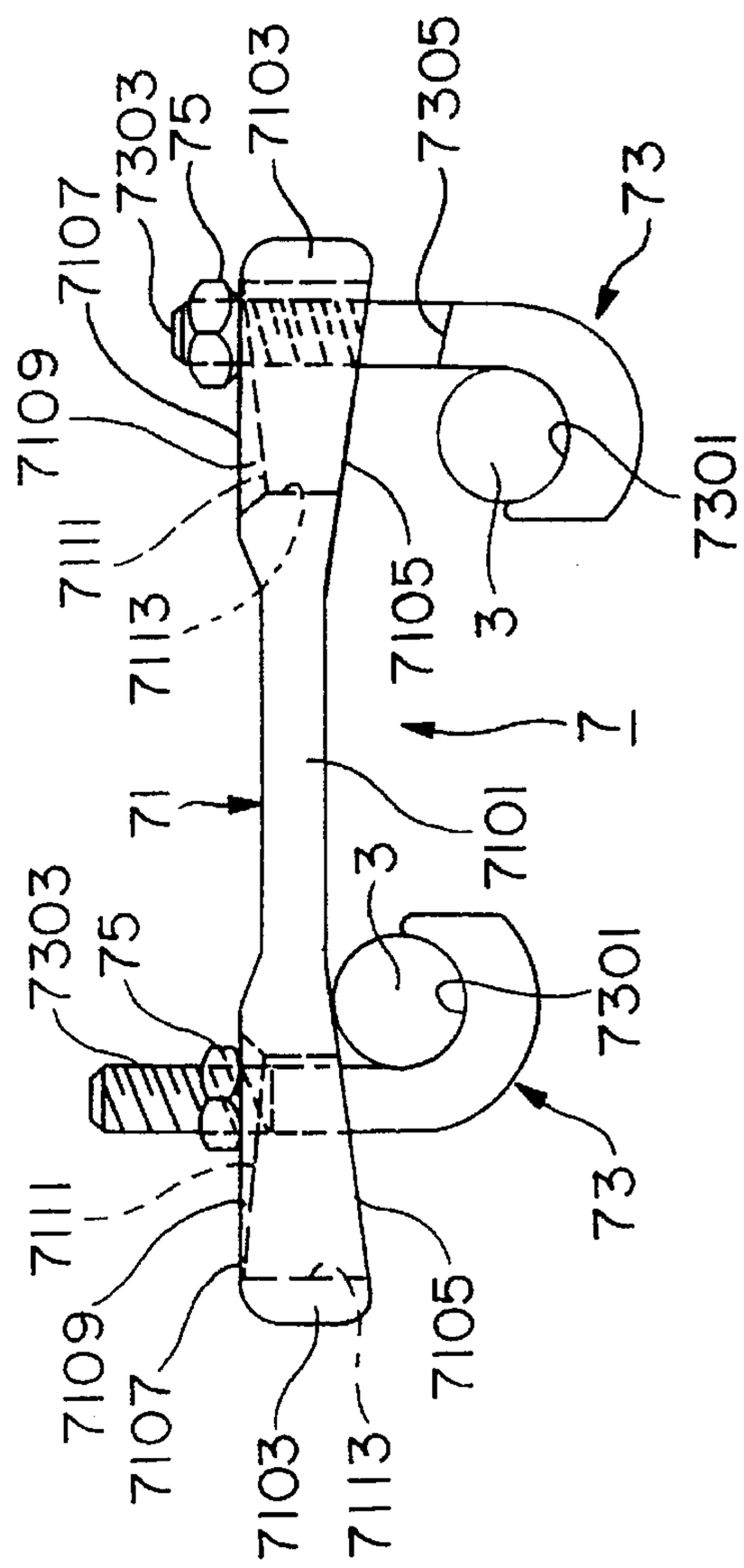


FIG. 7b

FIXING INSTRUMENT FOR SPINAL FUSION MEMBERS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a fixing instrument for a spinal fusion member that is used to secure spinal fusion members together, which are attached to both sides of a spine to correct a distortion of the spine.

2. Description of the Related Art

As one treatment for patients who suffer from spondylolisthesis, abnormal curvature of the spine and the like, corpus vertebrae which constitute a distorted spine are coupled together vertically by an elongated spinal fusion member and the distortion is corrected by the rigidity of the spinal fusion member.

In this case, a surgeon dissects the back of a patient to expose the vertebrae. Then, the spinal fusion members are fixed on the both sides of each of the vertebrae with screws secured to lengthwisely apart portions of the spinal fusion members.

Further, to correct the distortion of the spine in the twisting direction, a screw structure is laid out with the axis of the screw perpendicular to both spinal fusion members to apply them force in the direction approaching each other.

According to this method, however, only the peripheral surface of the screw Structure faces the dissected portion of a patient. Fastening the screw therefore requires gradual turning of a wrench in a narrow space formed in the patient's body by dissection, thus making the surgical operation troublesome.

SUMMARY OF THE INVENTION

A primary object of the present invention is to provide a fixing instrument for spinal fusion members, which is easily manipulatable, even if provided in a narrow space formed in a patient's body by dissection, from outside the body to apply force to both spinal fusion members to cause them to approach each other, thus contributing to simplification of a surgical operation.

To achieve the above object, according to this invention, there is provided a fixing instrument for mutually fixing a plurality of spinal fusion members to be secured over a plurality of vertebrae constituting a spine. The fixing instrument includes a connecting member to be laid across the plurality of spinal fusion members, a plurality of engagement members having engaging portions to engage with the spinal fusion members and provided on the connecting member slidably along the lengthwise direction thereof, moving members movable in a direction toward the corresponding engagement member, one end of each of the moving members positioned at the opposite side of the connecting member to the side where the engagement members are provided, and a conversion mechanism for converting the movement of the moving members to a one-way sliding movement of the engagement members in a direction approaching the corresponding spinal fusion member.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described below in detail with reference to the accompanying drawings in which:

FIG. **1** is an explanatory diagram showing a fixing instrument for posterior spinal fusion members according to a first embodiment of the invention in use;

FIGS. **2***a*, **2***b* and **2***c* are, respectively, a plan view, a front view and a side view showing the structure of the fixing instrument according to the first embodiment of the invention shown in FIG. **1**;

FIG. **3** is an exploded perspective view of a posterior spinal fusion member according to the first embodiment of the invention;

FIG. **4** is a cross-sectional view along the line IV—IV in. FIG. **1**;

FIG. **5** is a side view as viewed from the arrow V in FIG. **4**;

FIGS. **6***a*, **6***b* and **6***c* are, respectively, a plan view, a front view and a side view showing the structure of a fixing instrument according to a second embodiment of the invention shown in FIG. **1**; and

FIGS. **7***a*, **7***b* and **7***c* are, respectively, a plan view, a front view and a side view showing the structure of a fixing instrument according to a third embodiment of the invention shown in FIG. **1**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present disclosure relates to subject matter contained in Japanese utility model Application No. 5-74709 (filed on Dec. 28, 1993), which is expressly incorporated herein by reference in its entirety.

Preferred embodiments of the present invention will now be described referring to the accompanying drawings.

FIRST EMBODIMENT

Before describing posterior spinal fusion members according to this embodiment, names of each parts of individual vertebra **1** constituting a spine will be explained with reference to FIG. **4**. FIG. **4** shows a single vertebra **1** viewed from above (from the head side). A columnar corpus vertebra **12** is formed on front side (abdominal side) of the vertebra **1**. The corpus vertebra **12** is connected to the corpus vertebrae **12** of upper and lower adjoining vertebrae **1** via intervertebral disks. Formed at the rear side (dorsal side) of the corpus vertebra **12** is an arcus vertebra **14** which has an arcuate shape. The space defined between the arcus vertebra **14** and the Corpus vertebra **12** is a vertebral canal **16** in which a spinal cord runs. The portion where the arcus vertebra **14** is joined to the corpus vertebra **12** is called a pediculus arcus vertebra **15**. A spinous process **11**, protrudes rearward from the center portion of the arcus vertebra **14**. The pot%ions which project substantially sideward from right and left sides of the arcus vertebra **14** are called transverse process **13**.

FIG. **1** shows the spine constituted of the above-described vertebrae **1** from the dorsal side. FIG. **1** also shows two posterior spinal fusion members **3** and fixing instrument **5** according to this embodiment which are attached to the spinal column. The posterior spinal fusion members **3** ere secured by screws on the surfaces of the individual arcus vertebrae **14** which are both sides of the spinous processes **1** over a plurality of vertically arranged vertebrae **1**. More specifically, the posterior spinal fusion members **3** are fixed by screws at the positions of caps **31** shown in FIG **1**. The fixing instrument **5** having hooks (see FIG. **2**) is anchored to both posterior spinal fusion members **3** with the hooks. **53** hooked on the associated posterior spinal fusion members **3**. Each hook **53** is hooked on the associated posterior signal fusion member **3**.

A description will now be given of the structure of each posterior spinal fusion member **3** and the structure for securing the posterior spinal fusion member S with reference to FIG. **3**.

As shown in FIG. **3**, the posterior spinal fusion member **3** has a rod shape and has a plurality of washers **33** fixed at equal intervals along the axis thereof. Each washer **33** has a spherical surface. A pedicular screw **34** secures the posterior spinal fusion member **3** to the vertebra **1**.

The pedicular screw **34** has a cylinder portion **3401** at the top thereof. The inner diameter of the cylinder portion **3401** is larger than the outer diameter of the washer **33**. The washers **33** are therefore positioned in the associated cylinder portions **3401**. Formed in the cylinder portion **3401** of the pedicular screw **34** is a slit **3402** whose width is wide enough to pass the posterior spinal fusion member **3**, but not the washer **33**. That is, the cylinder portion **3401** has a forked shape. Female threads are formed in the inner wall of the cylinder portion **3401**. Male threads **3403** formed at the distal end of the pedicular screw **34** form a tapered screw.

A disk shaped setscrew **32** has male threads formed on the outer surface, which engage the female threads on the inner wall of the associated cylinder portion **3401**. Formed in the center of the upper end of each setscrew **32** is a hexagonal hole where a hexagonal wrench is insertable. Accordingly, with the posterior spinal fusion member **3** and the washers **33** fitted in the cylinder portions **3401**, as the setscrews **32** are engaged with the associated cylinder portions **3401**, the movement of the posterior spinal fusion member **3** is checked.

The caps **31** are put over the distal ends of the associated cylinder portions **3401** to protect the internal organs from the edges of the distal ends of the cylinder portions **3401**. Each cap **31** has a hole at the center thereof, through which the hexagonal wrench passes to drive the setscrew.

The fixing instrument **5** includes a connecting member **51** having a length corresponding to the distance between the pair of posterior spinal fusion members **3**, and a pair of hooks (corresponding to engagement members) coupled to both ends of the connecting member **51**, as shown in FIGS. **2***a*, **2***b* and **2***c*. A coupling mechanism for coupling the hook **53** to the connecting member **51** includes an elongated hole **5101** formed in either end of the connecting member **51**, a screw hole **5301** formed in the hook **53**, a screw or mounting member **55**, slide grooves **5115**, slide projections **5307** and an inclined surface **5103**. The individual parts of the securing instrument **5** will be described below.

The connecting member **51** has a rod-like shaft portion **5105** and hook support portions **5107** formed as flat square rods at both ends of the shaft portion **5105**. An engagement recess **5111** is formed in a bottom surface **5109** of each hook support portion **5107** as a straight groove elongated along the lengthwise direction of the shaft portion **5105**. The engagement recess **5111** has a flat bottom surface **5113** on both sides of which a pair of parallel elide grooves **5115** are formed facing each other. A recess **5119** is formed in a top surface **5117** of each hook support portion **5107** in an oval shape of which major axis is laid along the lengthwise direction of the shaft portion **5105**. The aforementioned inclined surface **5103** is formed as the bottom surface of the recess **5119**. The inclined surface **5103** is shallower on the side which is closer to the end of the securing instrument **51**, and is deeper on the side which is closer to the shaft portion **5105**. Further, the elongated hole **5101** is formed in the widthwise center of the inclined surface **5103** elongated along the lengthwise direction of the shaft portion **5105**. The elongated hole **5101** reaches the engagement recess **5111** through the hook support portion **5107**.

Each hook **53** has an arched engagement surface **5303** engageable with the associated posterior spinal fusion member **3**. The straight slide projections **5307**, which engage with the slide grooves **5115** of the engagement recess **5111**, are formed on both sides of the proximal end of each hook **53**. The screw hole **5301** is formed in substantially center of a flat surface **5305** at the proximal end of each hook **53**.

The screw **55** has a male thread portion **5501**, which engages with the screw hole **5301** of the hook **53**, and a head **5503**. The outside diameter of the head **5503** is slightly smaller than the width of the engagement surface **5103** of the recess **5119** and is larger than the width of the elongated hole **5101**. The head **5503** has a hemispherical bottom surface **5505**. When the head **5503** is located closer to the shaft portion **5105** in the recess **5119**, most of the head **5503** is retained in the recess **5119**. Formed in the end face of the head **5503** is a hexagonal hole where a hexagonal wrench is insertable.

To attach the hook **53** to the hook support portion **5107**, the slide projections **5307** and flat surface **5305** at the problem end of the hook **53** are respectively engaged with the slide grooves **5115** and flat surface **5113** of the hook support portion **5107**. At this time, the directions of both hooks **53** are adjusted in such a way that the engagement surfaces **5303** of the hooks **53** face each other. The hook **53** is slid on the hook support portion **5107** so that the screw hole **5301** of the hook **53** faces the elongated hole **5101** of the hook support portion **5107**. The screw **55** is fastened into the screw hole **5301** via the elongated hole **5101**.

As the flat surface **5305** and the slide projections **5307** of the hook **53** are respectively engaged with the flat surface **5113** and the slide grooves **5115** of the engagement recess **5111** of the connecting member **51**, even if the screw **55** is turned with respect to the connecting member **51** to be fastened, the hook **53** does not turn with respect to the connecting member **51**. This ensures smooth fastening of the hook **53** by the screw **55**.

The function of the fixing instrument **5** according to the first embodiment will be described below.

First, a surgeon dissects the back of a patient to expose the spine as shown in FIG. **1**. To fix the posterior spinal fusion members **3** to a plurality of vertebrae **1**, the surgeon drives the pedicular screw **34** into the associated vertebra **1** in such a way that the male thread portion **3403** moves toward the associated corpus vertebra **12** through the pediculus arcus vertebra **15** from the surface (dorsal-side surface) of the arcus vertebra **14**. In this manner, two pedicular screws **34** are driven into each of a plurality of vertebrae **1** at both sides of the spinous processes **11**. At the time the driving of the pedicular screws **34** is completed, the rotational positions of the pedicular screws **34** are adjusted such that the slits **3402** (formed in the cylinder portions **3401** of those pedicular screws **34**) are aligned with one another.

Next, the surgeon fits the washers **33** equal in number to the pedicular screws **34** over the associated posterior spinal fusion member **3**. The intervals between the individual washers **33** are adjusted in accordance with the intervals between the pedicular screws **34**. Then, the surgeon fits the washers **33** in the cylinder portions **3401** of the associated pedicular screws **34** with the posterior spinal fusion member **3** through the slits **3402**.

The setscrew **32** is engaged with the female threads on the inner wall of the cylinder portion **3401** of the associated pedicular screw **34** from the top of the cylinder portion **3401**.

The surgeon then places the cap **31** over the distal end of the cylinder portion **3401**. The surgeon further fastens the setscrew **32** to secure the washer **33** in the cylinder portion **3401**, with the hexagonal wrench made to pass through the hole of the cap **31** and engaged with the hexagonal hole of the setscrew **32**. The cylinder portion **3401** is widened according to the movement of the setscrew **32**, while securing the cap **31**. The structure for coupling the pedicular screw **34** driven in the arcus vertebra **14** of the vertebra **1** to the posterior spinal fusion member **3** is not limited to the illustrated type as other various conventional structures may be employed.

To secure the installing space for the fixing instrument **5**, the spinous processes **11** of the vertebra **1** where the fusion instrument **5** is to be anchored are cut off as shown in FIG. **5**.

To attach the fixing instrument **5** to the posterior spinal fusion member **3**, the surgeon first loosens the screws **55** fitted in both hook support portions **5107** to set the distance between both hooks **53** wider than the distance between both posterior spinal fusion members **3**. Under this condition, the surgeon inserts the fixing instrument **5** inside of the body of the patient (not shown) from the dissected portion at the back and makes the engagement surface **5303** of each hook **53** face toward the side of the associated posterior spinal fusion member **3**. At this time, the end face of the head **5503** of the screw **55** faces outward through the dissected portion of the patient, and the bottom surface **5505** of the head **5503** comes above the inclined surface **5103** of the inclined recess **5119**.

Under this condition, the surgeons inserts the distal end of a hexagonal wrench (not shown) in the body through the dissected portion, and engages it with the hexagonal hole formed in the end face of the head **5503** of the screw **55**. Then, the surgeon turns the hexagonal wrench from outside of the body to drive the screw **55** into the hook **53**. As the screw **55** is driven, the bottom surface **5505** of the head **5503** of the screw **55** abuts on the inclined surface **5103**. In the state that the fixing instrument **5** is attached to the individual posterior spinal fusion members **3**, the inclined surface **5103** formed in a recess formed in the top of the hook support portion **5107** of the connecting member **51** is inclined in such a way as to come away more from the associated vertebra **1** in consequence to approach the associated end of the connecting member **51**. When the screw **55** is further fastened from the state where the bottom surface **5505** of the screw head **5503** abuts on the inclined surface **5103**, the inclination of the inclined surface **5103** causes the head **5503** of the screw **55** to slide toward the shaft portion **5105** in the inclined recess **5119**. In accordance with this sliding action, the hook **53** also slides toward the shaft portion **5105**. The engagement surface **5303** of the hook **53** engages with the associated posterior spinal fusion member **3** from outside.

When the screw **55** is fastened further from the state where the engagement surface **5303** is in engagement with the associated posterior spinal fusion member **3**, the inclined action between the inclined surface **5103** and the bottom surface **5505** of the screw **55** causes the hook **53** to slide further toward the shaft portion **5105**. Accordingly, the force is applied to both posterior spinal fusion members **3** to cause those posterior spinal fusion members **3** to approach each other.

If the fixing instruments **5** are anchored to the posterior spinal fusion members **3** at a plurality of positions apart from one another at vertical intervals, the forces from those fixing instruments **5** act on those positions to correct the distortion between the upper and lower vertebrae **1** in the twisting direction.

According to this embodiment, as described above, the fixing instrument **5**, which is anchored to a pair of posterior spinal fusion members **3** laid over a plurality of vertically located vertebrae **1** on both sides of the spinous processes **11**, includes the connecting member **51**, the pair of hooks **53** slidably supported at both ends of the connecting member **51**, and the screws **55** which attach the hooks **53** to the connecting member **51**. The connecting member **51** includes the shaft portion **5105** and the flat hook support portions **5107** formed at both ends of the shaft portion **5105**. Further, the bottom of the recess **5119** formed in the top surface **5117** Of the hook support portion **5107** is formed as the inclined surface **5103**, which is inclined in such a way as to come away (i.e., to become shallower) from the associated vertebra **1** in consequence to approach the associated end of the connecting member **51**. The screw **55** is inserted through the elongated hole **5101** formed in the inclined surface **5103** to be engaged with the screw hole **5301** of the hook **53**.

Fastening the screw **55** therefore causes each hook **53** to slide toward the shaft portion **5105**. The sliding of the hooks **53** applies the force to the individual posterior spinal fusion members **3**, engaged with the engagement surfaces **5303** of the hooks **53**, to make the posterior spinal fusion members **3** approach each other. The force can easily and surely correct the distortion between the vertebrae **1**, which cannot be corrected by the posterior spinal fusion members **3** alone, in the twisting direction.

At the time the fixing instrument **5** is attached to the posterior spinal fusion members **3**, according to this embodiment, the end face of the head **5503** of the screw **55** faces outward through the dissected portion of the patient. Even if there is limited space around the screw **55** inside the patient's body, a screw fastening tool, such as a hexagonal wrench, can be manipulated without any problem. The Surgeon can thus easily perform an operation to slide the individual hooks **53** in the direction to approach each other. The surgeon can therefore conduct a surgical operation to apply force to the individual posterior spinal fusion members **3** to set them closer to each other.

SECOND EMBODIMENT

A second embodiment of the present invention will now be described with reference to FIGS. **6***a* to **6***c*. In those diagrams, the same reference numerals as used in FIGS. **2***a* through **2***c* are given to parts corresponding or identical to those of the first embodiment to avoid repeating their descriptions.

A recess **5121** is formed in the top surface **5117** of each hook support portion **5107** at a position closer to the shaft portion **5101** then the recess **5119**. The recess **5121** is formed in an oval form of which major axis is laid along the lengthwise direction of the shaft portion **5105**.

The bottom of the recess **5121** is formed as an inclined surface **5123**. Opposite to the direction of the inclination of the inclined surface **5103** of the recess **5119**, the inclined surface **5123** is deeper on the side which is closer to the end of the connecting member **51** and is shallower on the side which is closer to the shaft portion **5105**. That is, in the state that the fixing instrument **5**A is placed in e patient's body, the inclined surface **5123** is inclined in such a way that the inclined surface **5123** comes closer to the vertebra **1** in consequence to approach the end of the connecting member **51**. An elongated hole **5125** is formed In the widthwise

center of the inclined surface **5123** elongated along the lengthwise direction of the connecting member **51**. This elongated hole **5125** reaches the engagement recess **5111** through the hook support portion **5107**.

In addition to two hooks **53**A which engage the individual posterior spinal fusion members **3** from outside, similarly to the hooks **53** of the first embodiment, two additional hooks **53**B engage with the posterior spinal fusion members **3** from inside are attached to the associated hook Support portions **5107** of the fixing instrument **5**A. First, the flat surface **5305** and projections **5307** formed it the proximal end portion of each hook **53**B are engaged with the engagement recess **5111** (flat surface **5113** and slide grooves **5115**) of the associated hook support portion **5107** similarly to those of the hook **53** of the first embodiment. The directions of both hooks **53**B should be adjusted so that the engagement surfaces **5303** of the hooks **53**B face away from each other. The hooks **53**B are slid on the associated hook support portions **5107** so that the screw hole **5301** of each hook **53**B faces the elongated hole **5125** of the hook support portion **5107**. Then, the screw **55** is engaged with the screw hole **5301** through the elongated hole **5125**. The hooks **53**B are slidably attached to the hook support portions **5107** in the manner described above. The screws **55** are fastened to secure the hooks **53**B. The flat surface **5305** and the slide projections **5307** formed at the proximal end Of the hook **53**B are respectively engaged with the flat surface **5113** and the slide grooves **5115** of the engagement recess **5111** of the connecting member **51** as in the case of the hook **53** of the first embodiment. Even if the screw **55** is turned with respect to the connecting member **51** to be fastened, the hook **53**B does not turn with respect to the connecting member **51**. This ensures a smooth fastening of the hook **53** by the screw **55**.

The hooks **53**A are attached to the hook support portions **5107**. The flat surface **5305** and the slide projections **5307** formed at the proximal end of the hook **53**A are engaged with the engagement recess **5111** of the hook support **5107** the same manner as those of the hook **53** of the first embodiment. The screw **55** is engaged with the screw hole **5301**, formed in the proximal end of the hook **53**A, through the elongated hole **5101**. The hooks **53**A are slidably attached to the hook support portions **5107** in the manner described above. The screws **55** are fastened to secure the hooks **53**A. The hooks **53**A and the hooks **53**B, attached to the associated hook support portions **5107**, are arranged So that their engagement surfaces **5303** face each other.

The function of the fixing instrument **5** according to the second embodiment will be described below.

As in the first embodiment, the posterior spinal fusion members **3** are fixed to the vertebrae **1** of a patient. Then, the individual screws **55** of the fixing instrument **5**A are loosened to set the individual hooks **53**A and **53**B slidable on the associated hook support portions **5107**, and the poster posterior spinal fusion members **3** are positioned between the two paired hooks **53**A and **53**B. By further fastening the screws **55** engaged with the hooks **53**A from the above state, force is applied to the individual posterior spine fusion members **3** to cause those posterior spinal fusion members **3** to approach each other, similarly to the first embodiment.

By fastening the screws **55** engaged with the hooks **53**B thereafter, each posterior spinal fusion member **3** is held between the engagement surfaces **5303** of both of the hooks **153**A, **53**B. Accordingly, the distortion of the upper and lower vertebrae **1** in the twisting direction is corrected.

Therefore, the fixing instrument **5**A of the second embodiment can have the same advantages as the fusion instrument **5** of the first embodiment. Additionally, since the hooks **53**A and **53**B can be securely engaged with the posterior spinal fusion members **3**, it is advantageously possible to prevent the fixing instrument **5**A from coming off the posterior spinal fusion members **3**.

THIRD EMBODIMENT

A third embodiment of the present invention will now be described with reference to FIGS. **7***a* to **7***c*.

A fixing instrument **7**, according to the third embodiment, includes a connecting member **71** having a length corresponding to the distance between a pair of posterior spinal fusion members **3**, and a pair of hooks **73** (corresponding to engagement members) coupled to both ends of the connecting member **71**. The connecting member **71** has a rod-like shaft portion **7101** and hook support portions **7103** formed as square rods at both ends of the shaft portion **7101**.

The top surfaces of the hook support portions **7103** are level with each other. The bottom of each hook support portion **7103** is formed as an inclined surface **7105** inclined such that the nearer it comes toward the end of the connecting member **71** the more it comes away from the top surface. That is, in the state that the fixing instrument **7** is placed in a patient's body, the inclined surface **7105** is inclined such that the inclined surface **7105** comes closer to the vertebra **1** in consequence to approach the end of the connecting member **71**.

A recess **7109** is formed in a top surface **7107** of each hook support portion **7103** in an almond shape elongated along the lengthwise direction of the shaft portion **7101**. The bottom of the recess **7109** serves as an inclined surface **7111**, which is shallower on the side which is closer to the end of the connecting member **71** and is deeper on the side which is closer to the shaft portion **7101**. That is, in the state that the fixing instrument **7** is placed in the patient's body, the inclined surface **7111** is inclined such that the inclined surface **7111** comes away from the vertebra **1** in consequence to approach the end of the connecting member **71**. An elongated hole **7113** is formed in the widthwise center of the inclined surface **7111** elongated along the lengthwise direction of the connecting member **71**. The elongated hole **7113** penetrates through the bottom **7105** of the hook support portion **7103**.

Each hook **73** mentioned above has an arched engagement surface portion **7301** engageable with the associated posterior spinal fusion member **3**, and a male thread portion **7303**. The engagement surface portion **7301** has the shape of a square rod member bent in an arcuate form. The boundary between the engagement surface portion **7301** and the male thread portion **7303** is formed to have a narrower width, as shown in FIG. **7***c*. A shoulder **7305** formed by the narrowed width serves as an inclined surface inclined to be parallel to the bottom of the hook support portion **7103** in the state that the hook **73** is attached to the connecting member **71**. That is, in the state that the fixing instrument **7** is placed in the patient's body, the inclined surface **7305** is inclined such that the inclined surface **7305** comes closer to the vertebra **1** in consequence to approach the end of the connecting member **71**.

To attach each hook **73** to the above-described hook support portion **7103**, the male thread portion **7303** of the hook **73** is inserted in the elongated hole **7113**. At this time, the directions of both hooks **73** should be adjusted so that the engagement surface portions **7301** of the hooks **73** face each other. A nut **75** (equivalent to a female thread member) is

engaged with the male thread portion **7303** on the inclined surface **7111**. The bottom of the nut **75** is formed as a tapered, inclined surface **7501**. The hooks **73** are slidably attached to the associated hook support portion **7103** in the manner described above. The nuts **75** are fastened to secure the hooks **73**.

The function of the fixing instrument **7** according to the third embodiment will be described below.

As in the first embodiment, the posterior spinal fusion members **3** are fixed to the vertebrae **1** of a patient. Then, the individual nuts **75** of the fixing instrument **7** are loosened to slide the individual hooks **73** to set the distance between both hooks **73** wider then the distance between both posterior spinal fusion members **3**. Under this condition, the fixing instrument **7** is inserted into the body of the patient through the dissected portion at the back to position each posterior spinal fusion member **3** between the engagement surface portion **7301** of the associated hook **73** and the inclined surface **7105** of the associated hook support portion **7103**. The nuts **75** are then fastened.

The fastening of the nuts **75** causes the inclined surfaces **7305** of the hooks **73** to abut on the inclined surfaces **7105** of the associated hook support portions **7103**. Alternatively the posterior spinal fusion members **3** abut on the bottom surfaces **7105** of the associated hook support **7103**. It is the matter of design choice to make the inclined surface **7305** or the posterior spinal fusion member **3** abut on the inclined surface **7105** of the associated hook support portion **7103** first, or make both abut on the inclined surface **7105** simultaneously.

Further, fastening the nut **75** causes an inclined action between the inclined surface **7501** of the nut **75** and the inclined surface **7111** of the associated hook support portion **7103**, and also causes an inclined action between the inclined surface **7105** of the hook Support **7103** and the associated posterior spinal fusion member **3**. Those inclined actions slide the hook **73** toward the shaft portion **7101** along the elongated hole **7113**. Accordingly, force is applied to the individual posterior spinal fusion members **3** from the associated hooks **73** to cause both posterior spinal fusion members **3** to approach each other.

If the fixing instrument **7** is designed so that the inclined surface **7305** of the hook **73** abuts on the inclined surface **7105** of the associated hook support portion **7103** before the associated posterior spinal fusion member **3**, the engagement of the inclined surface **7305** with the inclined surface **7105** causes the hook **73** to slide, thus applying force to the individual posterior spinal fusion members **3** to approach each other.

Therefore, the fixing instrument **7** of the third embodiment can also have the same advantages as the fixing instrument **5** of the first embodiment. Like the second embodiment, the third embodiment has an advantage that the fixing instrument **7** can more surely be prevented from coming off of the posterior spinal fusion members **3**.

A part of the male thread portion **7303** of the hook **73** may be shaped to have a rectangular cross section, or flat portions may be formed at to locations 180 degrees apart from each other in the circumferential direction of the male thread portion **7303**, whereby the portion having the rectangular cross section or the flat portions engage with both side edges of the elongated hole **7113**. In this case, the thickness of the rectangular cross sectional port,ion or the thickness between the flat portions should be made slightly smaller than the width of the elongated hole **7113**. This restricts the rotation of the-hook **73** at the time the nut **75** is fastened, thus facilitating the fastening of the hook **73**.

According to the third embodiment, the force to shift the individual posterior spinal fusion members **3** toward each other is given by the cam action caused by the sliding contact of the inclined surface **7501** of the nut **75** with the inclined surface **7111** of the hook support portion **7103** or the cam action caused by the sliding contact of the inclined Surface **7305** of the hook **73** with the inclined surface **7111** of the hook support portion **7103**. The structure may be modified such that the force to shift the individual posterior spinal fusion members **3** toward each other is applied via the individual hooks **73** to those posterior spinal fusion members **3** by the inclined action caused by the sliding contact of the inclined surface **7105** of each hook support portion **7103** with the cam surface **7305** of the associated hook **73**.

Although the engagement surfaces **5303** end the engagement surface portions **7301** of the hooks **53**, **53**A, **53**B and **73** are formed in an arc Shape in the above-described embodiments, the structure of the hook may take various forms in accordance with the shape of the spinal fusion member and is not limited to those depicted in the sections of the individual embodiments.

In short, according to the present invention, the top of the screw head or the end face of the female thread member can be set to face toward the dissected portion of a patient. At the time of sliding the engagement member in the lengthwise direction of the connecting member to apply the force to the spinal fusion members securely fixed to both sides of the spinpus processes of the patient's spine to shift those spinal fusion members toward each other, a screw to drive the engagement member or a tool to fasten a female thread member can easily be manipulated without any problem within a narrow space inside the patient's body.

What is claimed is:

1. A fixing instrument for spinal fusion members for mutually fixing a plurality of spinal fusion members to be secured over a plurality of vertebrae constituting a spine, comprising:

an elongated connecting member, having a on longitudinal axis to be positioned across said plurality of spinal fusion members along said longitudinal axis;

a plurality of engagement members each having engaging portions to engage said spinal fusion members, said engagement members provided on said connecting member and being slidable along said longitudinal axis of said connecting member;

moving members, engaging said engagement members and said connecting member, that are movable in a first direction transverse to said longitudinal axis of said connecting member, by an external operation; and

conversion means on said connecting member for converting the movement of said moving members from said first transverse direction to the sliding movement of said engagement members along said longitudinal axis of said connecting member.

2. The fixing instrument for spinal fusion members according to claim **1**, wherein said plurality of engagement members includes first and second engagement members, said sliding movement of said first engagement member being in a direction approaching said second engagement member.

3. The fixing instrument for spinal fusion members according to claim **1**, wherein said engaging portions comprise hooks, said engaging portions being attached to said moving members, wherein upon said sliding movement of said engagement members along said longitudinal axis of said connecting member, said hooks engage said spinal fusion members.

4. The fixing instrument for spinal fusion members according to claim 3, wherein said plurality of engagement members comprise:

plural pairs of engagement members provided on said connecting member, each pair of said plural pairs of engagement members having a pair of said hooks, wherein a first hook of each of said pair of hooks faces a second pair hook of each of said pair of hooks so that each of said spinal fusion members is clamped between said first and said second hooks of one of said pairs of engagement member.

5. The fixing instrument for spinal fusion members according to claim 1, wherein each of said moving members has a male thread and a head connected to said male thread;

each of said engagement members has a female thread formed to engage with said male thread; and

said connecting member has a first and second slot, wherein at least one of said male threads passes through said first slot and at least another of said male threads passes through said second slot.

6. The fixing instrument for spinal fusion members according to claim 5, wherein said conversion means further comprises:

first and second surfaces adjacent each of said first and second slots, wherein said engagement members slide along said first surfaces, and said heads of said moving members slide along said second surfaces; and

wherein said conversion means further include a gradually varying thickness between each of said first and second surfaces.

7. The fixing instrument for spinal fusion members according to claim 6, wherein each of said second surfaces is a bottom surface of a recess formed in said connecting member adjacent one of said pair of slots, and wherein each said bottom surface comprises an inclined surface.

8. The fixing instrument for spinal fusion members according to claim 1, wherein each of said moving members comprises a nut having a female thread formed therein;

each of said engagement members comprises a male thread formed to engage with said female thread; and

said connecting member comprises a first and second slot, wherein at least one of said male threads passes through said first slot and at least another of said male threads passes through said second slots.

9. The fixing instrument for spinal fusion members according to claim 8, wherein each of said pair of slots passes through an upper surface and a lower surface of said connecting member;

wherein each of said engagement members moves along one of said upper and lower surfaces through which one of said pair of slots passes;

wherein each said nut of each of said moving members moves along the other of said upper and lower surfaces through which one of said pair of slots passes; and

wherein a thickness between said upper surface and said lower surface through which each of said pair of slots passes gradually varies.

10. The fixing instrument for spinal fusion members according to claim 9, wherein each of said one of said upper and lower surfaces along which said engagement members move is an inclined surface which is adapted to allow sliding of one of the spinal fusion members therelong, when said engagement members engage with the spinal fusion members.

11. The fixing instrument according to claim 1, wherein each of said moving members is a screw which engages a screw hole provided in each of said engagement members, said fixing instrument further including preventing means comprising a male thread provided on each said screw and a female thread provided on an inner surface of each said screw hole, for preventing said movement of said moving members in said longitudinal direction unless said male threads are moved with respect to said female threads.

12. The fixing instrument for spinal fusion members according to claim 1, further comprising:

means for preventing a movement of said moving members in direction opposite to said longitudinal direction.

13. A fixing instrument for spinal fusion members for mutually fixing a plurality of spinal fusion members to be secured over a plurality of vertebrae constituting a spine, comprising:

a connecting member to be positioned across said plurality of spinal fusion members, said connecting member comprising an elongated hole formed near a first end of said connecting member and extending in a longitudinal direction of said connecting member;

an engagement member attached to said first end of said connecting member, said engagement member having an engaging portion to engage one of said spinal fusion members, said engagement member being slidable along said longitudinal direction of said connecting member;

a moving member which connects with said engagement member through said elongated hole, said moving member being movable in a direction transverse to said longitudinal direction of said connecting member; and

conversion means on said connecting member for converting the movement of said moving member in said direction transverse to said longitudinal direction to the movement of said engagement member in a direction substantially aligned with said longitudinal direction of said connecting member.

14. A fixing instrument to be anchored to a pair of elongated spinal fusion members attached on both sides of spinous processes of a plurality of vertebrae positioned vertically and arranged along a direction of said vertebrae, comprising:

a connecting member formed to have a length corresponding to a distance between said pair of spinal fusion members, said connecting member having first and second ends;

a pair of first engagement members, one of said pair of first engagement members being coupled to said first end of said connecting member, and the other of said pair of first engagement members being coupled to said second end of said connecting member, said pair of first engagement members adapted to be engaged with said spinal fusion members; and

coupling means for coupling said engagement members to said connecting member, said coupling means comprising:

recesses formed in said first and second ends of said connecting member, said recesses each having a predetermined length in a longitudinal direction of said connecting member and each comprising an inclined bottom surface, wherein each said inclined surface makes each said recess deeper within said connecting member, at an end of said predetermined length nearer a center of said connecting member, than at an end of said predetermined length nearer one of said first and second ends of said connecting member;

an elongated hole formed in each of said inclined bottom surfaces and extending in said longitudinal direction;

a screw hole formed in a top surface of each of said first engagement members;

a screw insertable through each of said elongated holes, each said screw comprising a head corresponding to a diameter of each of said respective recesses, capable of contacting each said bottom surface of each said recess, wherein said screws are inserted into said elongated holes to engage with said screw holes.

15. The fixing instrument for spinal fusion members according to claim **13**, further comprising:

a pair of second engagement members, wherein one of said pair of second engagement members is coupled to a portion of said connecting member adjacent one of said pair of first engagement members, and the other of said pair of second engagement members is coupled to a portion of said connecting member adjacent the other of said pair of first engagement members, for holding spinal fusion members in cooperation with said pair of first engagement members, wherein each of the spinal fusion members is held by one of said pair of first engagement members and one of said pair of second engagement members; and

second coupling means for coupling said pair of second engagement members to said connecting member, said second coupling means comprising:

second recesses formed near said first and second ends of said connecting member, said second recesses each having a second predetermined length in a longitudinal direction of said connecting member and comprising a second inclined bottom surface, wherein each said second inclined surface makes each said second recess deeper within said connecting member, at an end of said predetermined length nearer one of said first and second ends of said connecting member than at an end of said predetermined length nearer a center of said connecting member;

a second elongated hole formed in each of said second inclined bottom surfaces and extending in said longitudinal direction;

a second screw hole formed in a top surface of each of said second engagement members;

a screw insertable through each of said second elongated holes, each said screw comprising a head corresponding to a diameter of each of said respective second recesses, capable of contacting each said second bottom surface of each said second recess, wherein said second screws are inserted into said second elongated holes to engage with said second screw holes;

wherein advancing said screws into said screw holes and said second screws into said second screw holes biases said first and second engagement members toward one another, along said longitudinal direction, to engage and hold the spinal fusion members.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 5,569,246

DATED : October 29, 1996

INVENTOR(S) : S. OJIMA et al.

It is certified that error appears in the above-indentified patent and that said Letters Patent is hereby corrected as shown below:

At column 10, line 37 (claim 1, line 5), delete "on".

At column 11, line 8 (claim 4, line 8), delete "pair" (first occurrence).

At column 11, line 11 (claim 4, line 11), change "member" to ---members---.

At column 12, line 11 (claim 12, line 4), after "in" insert ---a---.

Signed and Sealed this

Thirteenth Day of May, 1997

Attest:

BRUCE LEHMAN

Attesting Officer

Commissioner of Patents and Trademarks